METHOD AND APPARATUS FOR DIRECTIONAL DRILLING

TECHNICAL FIELD

The present invention is directed at directional drilling and, more specifically, at a method and apparatus for use in directional drilling.

BACKGROUND OF THE INVENTION

In the past, in order to lay down underground pipelines, trenches were dug and the pipes were placed in the bottom of the trenches. After the pipes had been leveled, the trenches were generally re-filled with the ground that had been previously dug up.

However, more recently, directional drilling has been used to drill holes underground to assist in the laying down of pipelines and other utilities so that less work is required to re-fill trenches.

In directional drilling, a large hole is initially dug out to align with the depth that the pipe is to be installed so that the directional drilling apparatus may be assembled. Prior to operation, a motor is connected to a mandrel which is used to create a guide line along which the pipe is to be laid down. The motor causes the mandrel to rotate creating a small hole. The directional drilling apparatus may further comprise means for aligning the mandrel and for constantly watching the digging of the guide line. The drilling of the guide line results in a small hole being created from the location of the motor to the large hole. After the mandrel reaches the large hole, a reamer is connected to the mandrel along with the pipe that is to be laid down. The motor is once again enabled to rotate the mandrel and to draw the mandrel, reamer and pipe. This requires a number of increasingly larger passes at which time the reamer and pipe are pulled towards the motor. The rotation of the motor causes the size of the guide line hole to increase allowing the pipe to be laid down.

During the hole producing process, liquid, in the form of bentonite or other drilling fluid is released via jets in the drilling apparatus. The bentonite mixes with the ground to create a slurry which is passed backwards against the surface of the pipe to the large hole. In order to provide space for the slurry to travel, the circumference of the reamer is generally one and half times larger than the circumference of the pipe. This extra space allows the slurry to travel towards the hole but also allows for frac-outs to occur. A frac-out is the uncontrolled spilling of drilling fluids, usually bentonite, into the environment. This happens when the hole being drilled fractures or collapses and the fluids that are used to lubricate the drill seep out of the hole. Frac-outs can be devastating to the environment.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to obviate or mitigate at least one disadvantage of previous methods and apparatus for directional drilling.

In a first aspect, the present invention provides a pullhead/reamer for use in digging a hole in the ground; comprising a first end shaped to receive a mandrel; a second end shaped to fit around an end of a pipe; a set of struts, connecting the first end to the second end, the struts defining a set of open flutes therewithin; and a set of slurry jets; wherein when the pullhead/reamer is in use, the set of slurry jets release a pressurized liquid to mix with the ground producing a slurry which enters the pullhead/reamer via the open flutes.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1a is a schematic diagram of prior art pilot hole drilling apparatus;

Figure 1b is a schematic diagram of a second embodiment of prior art pilot hole drilling apparatus;

Figure 2 is a schematic diagram of pullhead/reamer directional drilling apparatus installed in the ground

Figure 3 is a more detailed schematic diagram of the pullhead/reamer directional drilling apparatus of Figure 2;

Figure 4 is a schematic diagram of a pullhead/reamer for use with the present invention;

Figure 5 is a front view of the pullhead/reamer of Figure 4;

Figure 6 is a more detailed view of how the directional drilling apparatus is attached;

Figure 7 is a flowchart illustrating a method of directional drilling in accordance with the present invention; and

Figure 8 is a schematic view of second embodiment apparatus for performing the method of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Turning to Figure 1a, a schematic diagram of prior art directional drilling apparatus for producing a pilot/guide hole (after the pilot hole has been dug) is shown. In this pilot hole drilling apparatus, two large holes **10a** and **10b** are initially dug out of the ground with its bottom edge **12** located below a depth **14** for a pipe to be installed. Once the first hole **10a** is dug, a motor **16** is placed in the hole **10a** and connected to one end of a mandrel **18** which has a drill bit **20** connected at its other end. The mandrel **18** is preferably hollow so that drilling liquid may be passed from the first hole **10a** to the second hole **10b** during the pipe hole drilling process. The drill bit **20** is preferably attached to the mandrel **18** via a screw fitting so that the drill bit **20** may be screwed on and unscrewed off when necessary as will be described below.

After the second hole **10b** is dug, the motor **16** is started in order to rotate the mandrel **18** and the drill bit **20**. The drill bit **20** then rotates through the ground from the first hole **10a** to the second hole **10b** to produce a pilot hole, which is used as a guide for the pipe hole drilling apparatus, from the first hole **10a** to the second hole **10b**. After the drill bit reaches the second hole **10b**, the drill bit **20** is unscrewed so that the pipe hole drilling apparatus may be attached.

Although not shown, the pilot hole directional drilling apparatus may further comprise means for aligning the drill bit during the pilot hole drilling process and means for monitoring the digging of the hole to ensure that the pilot hole drilling apparatus remains aligned.

Turning to Figure 1b, which shows a second embodiment of prior art pilot hole drilling apparatus, although shown as being located in the first hole **10a**, the motor **16** may also be located on the ground's surface with the drill bit **20** entering the ground at a diagonal slope before being shifted so that the guide hole being drilled is substantially parallel to the Earth's surface. It will be understood that in this embodiment, the mandrel **18** has a sloped shape which, in combination with existing electrical equipment, may be steered by an experienced operator.

Turning to Figure 2, a schematic diagram of pullhead/reamer, or pipe hole, directional drilling apparatus for laying down the pipe is shown. After the drill bit has been unscrewed from the mandrel, a first end **22** of a pullhead/reamer **24** is screwed onto the mandrel **18**. A second end **26**, seen as a grade ring, of the pullhead/reamer **24** is attached to a steel connect **28** which serves as a connection between the pullhead/reamer **24** and a pipe **30** which is to be installed into a hole produced by the

directional drilling process. The pullhead/reamer **24**, the steel connect **28** and the pipe **30** are shown in cross-section in Figure 2.

The steel connect **28** is connected to the mandrel **18** via a bearing assembly **32** which assists in allowing the pullhead/reamer **24** to be rotated by the motor **16** during the pipe hole directional drilling process while reducing or eliminating rotation of the pipe **30** during the same process.

In the first hole **10a**, or at the location of the motor **16**, a pump **34** is located along with a reservoir **36** containing a drilling fluid **38**, such as bentonite. The reservoir **36** and the pump **34** are connected to the end of the mandrel, via piping **40** for pumping the bentonite down through the mandrel during the pipe hole directional drilling process.

Furthermore, although not shown, a conventional reamer may be connected to the mandrel **18** in front of the first end **22** of the pullhead/reamer **24** to provide further assistance in drilling the pipe hole with the circumference of the conventional reamer being the same as the circumference of the pullhead/reamer **24**. In general, the conventional reamer has a threaded connection which attaches to the mandrel and then to the pullhead/reamer **24**.

The pilot/guide hole, substantially a straight line, produced by the mandrel and drill bit serves as an assistance to the pipe hole directional drilling apparatus in aligning the mandrel **18** and the pullhead/reamer **24** so that the hole that is dug by the pipe hole drilling apparatus for placing the straight pipe **30**.

After the first end of the pullhead/reamer **24** is attached to the mandrel **18**, the steel connect **28** is attached to the mandrel **18** using the bearing assembly **32**. The steel connect **28** is then attached to the pipe **30** via a set of fastening means **42**, such as a set of screws.

After the pipe **30** has been attached, the motor **16** is once again enabled to rotate the mandrel and the pullhead/reamer and to draw the mandrel **18**, pullhead/reamer **24**, steel connect **28** and pipe **30** towards the motor **16** along the guide hole. The rotation of the pullhead/reamer (and conventional reamer, if present) along the guide hole causes the size of the pilot hole to increase, from the circumference of the drill bit to the larger circumference of the pullhead/reamer **24**, allowing the pipe **30** to be laid down since the pullhead/reamer is both designed to dig through the ground to create holes as described and shown in more detail in Figure 4.

Turning to Figure 3, a more detailed schematic diagram of the pipe hole directional drilling apparatus described above is shown. As will be understood, although notshown, the conventional reamer may be easily slotted over the mandrel **18** between

the motor **16** and the pullhead/reamer **24**. The motor **16**, the mandrel **18** and the pullhead/reamer **24** may be seen as holing means **44**.

The second end **26** of the pullhead/reamer **24**, which is connected to the pipe **30**, via the steel connect **28**, comprises an outer circumference which is slightly larger than the outer circumference of the pipe **30** so that the pipe hole drilled by the pullhead/reamer **24** is large enough for the pipe **30** to travel within. Unlike prior art pipe hole drilling apparatus which generally require a reamer which has a circumference which is one and a half times the circumference of the pipe being inserted, there is only a slight difference, of about 2 inches, between the circumferences of the pullhead/reamer **24** of the present invention and the pipe **30**. This allows for a smaller hole to be drilled by the holing means **44** and to reduce the chance of a frac-out occurring. Furthermore, the pipe **30** may be installed with little or no obstruction such as the extra ground which is displaced when using only a conventional reamer. It is understood that the selection of the conventional reamer for use with the pullhead/reamer **24** of the present invention is based on the circumference of the pullhead/reamer **24** and not the circumference of the pipe **30** which overcomes some of the disadvantages of prior art directional drilling apparatus.

Turning to Figure 4, a more detailed schematic of the pullhead/reamer is shown. The pullhead/reamer **24** comprises the first end **22** which includes a mandrel connecting area, having an inner shape matching the outer shape of the mandrel and internal threads so that the pullhead/reamer **24** is screwed on to the mandrel, and the second end **26** which includes a steel connect connecting area, having an inner circumference which is slightly larger than the outer circumference of the steel connect so that the steel connect **28** is slotted into second end **26**.

The first end **22** is connected to the second end **26** via a set of integrally formed struts **46**. The spacing between each of the struts also defines a set of open flutes or ports **48**.

Also located at the second end **26** is a set of slurry producing jets **50** which release a drilling fluid, preferably bentonite, during the pipe hole drilling process to mix with the ground to create a slurry. The slurry producing jets **50** provide almost pure bentonite mixture to lubricate the ground, the surface of the pullhead/reamer **24**, the steel connect **28** and the pipe **30** allowing the parts to more easily slide along the newly dug hole.

As further shown in Figure 4, located on the outer surface of the first end **22**, the set of struts **46** and the second end **26** are a set of cutting teeth **52** which assist in the pipe hole directional drilling process to drill the hole in the ground. The teeth **52** provide further support and strength in creating the hole such that when the pullhead/reamer **24** is

rotated, there is more friction between the pullhead/reamer **24** and the ground to remove the ground away from the hole. .

Turning to Figure 5, a front view of the pullhead/reamer **24** is shown. As can be seen, the first and second ends are both circular with the first end **22** being smaller than the second end **26**. As discussed above, the size of the first end is defined by the circumference of the mandrel **18** being used while the size of the second end is defined by the circumference of the pipe **30** being installed. As more clearly seen in this Figure, the set of struts **46** form a spoke-like pattern so that each of the open flutes/ports **48** is evenly defined. It will be understood that the set of struts **46** do not need to be so evenly spaced but simply that open flutes **48** are defined for the slurry to enter the pullhead/reamer **24** and the subsequently, the steel connect **28** and the pipe **30** during the pipehole directional drilling process.

Turning to Figure 6, a detailed schematic of the connection between the pipe and the mandrel and pullhead/reamer is shown in cross-section. The pullhead/reamer **24** is screwed onto the end of the mandrel **18** after the drill bit has been removed. After the pullhead/reamer **24** has been attached, the steel connect **28** is then attached to the mandrel **18** via the bearing assembly **32** comprising a set of bearings **54** and associated supports **56**. A set of teflon wear pads **58** are preferably placed between the inside of the pullhead/reamer **24** and the outside of the steel connect **28** in order to prevent the drilling fluid from re-entering the pullhead/reamer after it has been released by the jets **50** and to prevent wear and tear between the pullhead/reamer **24** and the steel connect **28** during the pipe hole directional drilling process since the pullhead/reamer **24** is rotating while the steel connect **28** is stationary (with respect to rotation). The bearings **54** are slotted over the mandrel **18** with their supports **56** fastened to the inside of the steel connect **28**. The ends of the supports **56** which contact the inside of the steel connect **28** are preferably welded to the steel connect **28**.

In this embodiment, the steel connect **28** is connected to the pipe **30** via the fastening means **42**, seen as screws, in order to provide a sturdy connection between the steel connect **28** and the pipe **30**. In most cases, since the integrity of the pipe is harmed by having a hole within (caused by the fastening means **42**), when the pipe has been placed in the new hole, the end of the pipe **30** containing the hole is cut off to remove the holes caused by the screws.

In this figure, the slurry jets **50** may be more clearly seen. The bentonite is delivered from the reservoir, via the pump, down through the inside of the mandrel to a manifold **64** at the front of the pullhead/reamer **24** which the distributes the bentonite to the slurry jets **50**. The flow of the bentonite is more clearly shown by arrows **66**.

In operation, as shown in Figure 7, for the pipe hole drilling process, after the pullhead/reamer **24**, steel connect **28** and the pipe **30** have been attached to the mandrel **18** (**step 100**), the motor is re-enabled and the pump **34** enabled (**step 102**) which causes all of the apparatus to be slowly drawn towards the motor along the previously drilled guide hole. Since the pipe **30** is also attached to the mandrel **18**, via the steel connect **28**, as the pullhead/reamer **24** moves forward in the guide hole towards the motor, the pipe **30** is also pulled and travels along the hole towards the motor. As the apparatus travels along the guide hole, the motor causes the mandrel to rotate which, in turn causes the pullhead/reamer to rotate and for the digging of the pipe hole to begin (**step 104**). As described above, the pipe **30** and the steel connect **28** do not rotate. The connection between the steel connect **28** and the bearing assembly **32** assist in this manner since the bearing assembly **32** allows the mandrel to rotate within without causing the steel connect **28** to rotate. This provides further protection from any possible wear and tear between the outside of the pipe and the ground.

The pullhead/reamer **24** rotates around the stationary (with respect to rotation) steel connect **28** with the wear pads **58** absorbing the friction to reduce wear and tear on the steel connect **28** and the pullhead/reamer **24**. As the apparatus is drawn back toward the motor **16**, the rotation of the pullhead/reamer **16** causes the ground to be displaced since the set of teeth **52** located on the surface of pullhead/reamer **24** contacts the ground producing a hole having a diameter approximately equal to the diameter of the pullhead/reamer.

Once the motor has been re-enabled to begin the pipe hole drilling process, the pump **34** begins to operate to pump the drilling fluid **38** from the reservoir **36** to the slurry jets **50** via the mandrel **18** and the manifold **66**. While the pipe hole is being drilled, the slurry jets **50** receive the drilling fluid, such as Bentonite, and releases it into the ground to interact with the displaced mud and form a slurry (**step 106**). The provision of the Bentonite reduces the chance of frac-outs by moisturizing the ground around the pipe hole direction drilling apparatus and lubricating the pipe. While the pullhead/reamer **24** is rotating, it causes the slurry to enter the pullhead/reamer **24** via the flutes **48** located in its surface after which the slurry is then forced into the steel connect **28** and pipe **30** (**step 108**). In the preferred embodiment, the pump **34** and reservoir **36** are connected to the mandrel **18** through the motor **16**. The pullhead/reamer maintains the hole in the ground by deflecting all of the mud and slurry away from the hole and to the flutes.

Pressure from the released bentonite by the slurry producing jets **50** also causes the slurry to enter the pipe **30** via the set of open flutes **48** defined by the struts 46. The constant pressure from the slurry created by the jets **52** causes the slurry within the pipe

and to travel down the pipe **30** to the opposite end whereby the slurry may be collected and disposed by various means (**step 110**). In some cases, the collected slurry may be transported off-site. Alternatively, the bentonite, or drilling fluid, is recycled.

By causing the drilling fluid to drain through the inside of the pipe, via the open flutes **48** of the pullhead/reamer, allows for the circumference of the pullhead/reamer to be smaller than reamers used in prior art pipe hole directional drilling apparatus. In conventional directional drilling apparatus, to dig a 24 inch hole generally requires a 36 inch reamer. In the present invention, to dig a 24 inch hole requires a pullhead/reamer having a circumference of about 26 inches and preferably a single pass. Furthermore, in most prior art cases, to dig the 24 inch hole requires prior passes using a 16 inch reamer and a 24 inch reamer before using the 36 inch reamer to dig the final holes which totals at least three passes to dig a hole large enough to insert the pipe. Furthermore, with prior art processes, the hole must then be filled once the pipe has been inserted into the hole which require further time in completing the directional drilling process.

Although not shown, a smaller pipe may be placed inside the pipe **30** for receiving the slurry created by the mixing of ground and bentonite. In order to cause the slurry to enter the smaller pipe, a funnel may be placed within the steel connect **28** to guide the slurry towards the smaller pipe while the pipe **30** is being drawn by the motor. In this manner, the integrity of the inside of the pipe may be maintained so that the life of the pipe **30** may be extended. After the pipe hole drilling process is completed, the smaller pipe may be removed from the pipe.

Once the mandrel and pullhead/reamer have reached the original start of the guide hole, i.e. the first hole **10a**, the pipe **30** is detached from the steel connect **28** and laid within the hole. The end of the pipe **30** may then be cut to remove the holes created by the fastening means **42** attaching the pipe **30** to the steel connect **28**. The motor **16**,m the pump **34**, the reservoir **36** and the piping **40** are then moved to the next hole so that a new guide line may be dug and the process repeated. The end of the pipe **30** which was just laid down may then be attached with an end of the pipe to be laid down in the next hole using known processes.

It will be understood that the pipe does not have to be detached from the mandrel **18**, the pullhead/reamer **24** and/or the steel connect **28** if the length of the pipe **30** is ~~longer~~ than the hole produced by the pipe hole directional drilling apparatus and is intended to be laid down in the subsequent hole as well.

In another embodiment of the present invention, as shown in Figure 8, a reamer **112** is connected to a mandrel **114**. A pipe **116** is then connected to the end of the mandrel **114** via known means such as a bearing assembly **118** comprising a set of

support beams **120** which are connected to the inside of the pipe **116** to pull the pipe along as the hole is drilled. As the hole is being drilled, a drilling fluid, such as bentonite, is released from a set of jets **122** located on the surface of the reamer **112** to create a slurry between the mud and the bentonite. As the pipe **116** is being pulled, the slurry is then caused to enter the pipe **116**. The pressure from the slurry entering the pipe causes the slurry to flow down the pipe in a direction opposite the direction of the reamer and pipe. The slurry may then be removed from the end of the pipe. As described above, by having the slurry travel inside the pipe, a smaller reamer may be used to produce a hole for the pipe to be inserted compared to processes in the prior art. In the prior art processes, larger holes were required so that the slurry may flow away from the hole being drilled along the outer surface of the pipe. Therefore the extra space was to protect frac-outs from occurring.

The method and apparatus of the present invention provides an advantage over the prior art such that the design allows the pullhead/reamer to rotate providing a secondary reamer action to the conventional reamer but eliminating the actual pullhead concept since conventional reamers are generally a closed sealed pullhead. The reamer/pullhead is designed with openings to the inside of the pipe allowing the slurry to flow internally through the pipe.

Further advantages for directional drilling apparatus are realized by the pullhead/reamer of the present invention. Firstly, frac outs are generally reduced or eliminated which assist in preserving nature and by protecting the environment from harmful chemicals. Secondly, the present invention allows for a reduced product hole (the size of the hole which is dug out in order to install the piping from 1.5 times the diameter of the pipe to a hole which is only slightly larger than the circumference of the piping. Also, the pullhead/reamer of the present invention may allow for a single pass operation in order to reduce the amount of time necessary to dig the holes to install the piping. Another advantage is that there is a greater opportunity to increase slurry/native conversion rate due to the fact that the slurry is controlled in the pipe head. Yet another advantage is that when the directional drilling is in operation for grade work, there is greater control of the pipe that is being installed. Finally, the present invention provides a better means for control of fluids which are being used during the directional drilling process in order to alleviate ~~environmental concerns~~.

Another advantage of the present invention is that the process of performing directional drilling with the mud, via the slurry, being removed internally through the pipe rather than externally along the surface of the pipe allows for less passes to be required and smaller parts needed. This both saves time and money for the users.

The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

5